RESEARCH DEPARTMENT

LONG DISTANCE OVERLAND TROPOSPHERIC PROPAGATION MEASUREMENTS AT 495 AND 560 Mc/s

Report No. K-149

(1960/30)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

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SUMMARY

This report presents the results of field strength measurements on u.h.f. transmissions on 495 Mc/s and 560 Mc/s over land paths at distances up to 294 miles (473 km). These measurements extended over a period of approximately three years and have been used in the preparation of field strength/distance curves for various percentages of the overall time.

The results are compared with the measurements at 180·4 Mc/s made over similar transmission paths and reveal a significant dependence of field strength on frequency.

The measurements were used by Study Group V of the C.C.I.R. in the preparation of field strength curves for tropospheric propagation at distances beyond the horizon.

1. INTRODUCTION

To operate common channel u.h.f. transmitters with the minimum amount of mutual interference information is required on the magnitude and duration of occurrence of signals propagated over long distances.

Long distance propagation tests were started by the B.B.C. Research Department in 1947 and measurements have been made since then within the frequency range of 30–300 Mc/s.[1, 2, 3, 4, 5] Band IV was allocated for broadcasting by the I.T.U. at Atlantic City in 1947 and, because of the B.B.C.'s interest in this band, experiments were started to determine to what extent long distance tropospheric propagation is dependent upon frequency, and to obtain comparison with the results of earlier tests.

In 1951 the C.C.I.R. began a Study Programme on tropospheric wave propagation at distances well beyond the horizon. Measurements made by the B.B.C. have contributed to this programme. Further data on higher frequencies were required to supplement that already available in the United Kingdom and other countries. This report covers the measurements made on 495 Mc/s and 560 Mc/s during the period from March 1955 to June 1958.

2. TRANSMISSION PATHS

The transmitters were sited originally at Sutton Coldfield and Holme Moss with receiving sites in operation at Mursley in Buckinghamshire, Kingswood Warren in

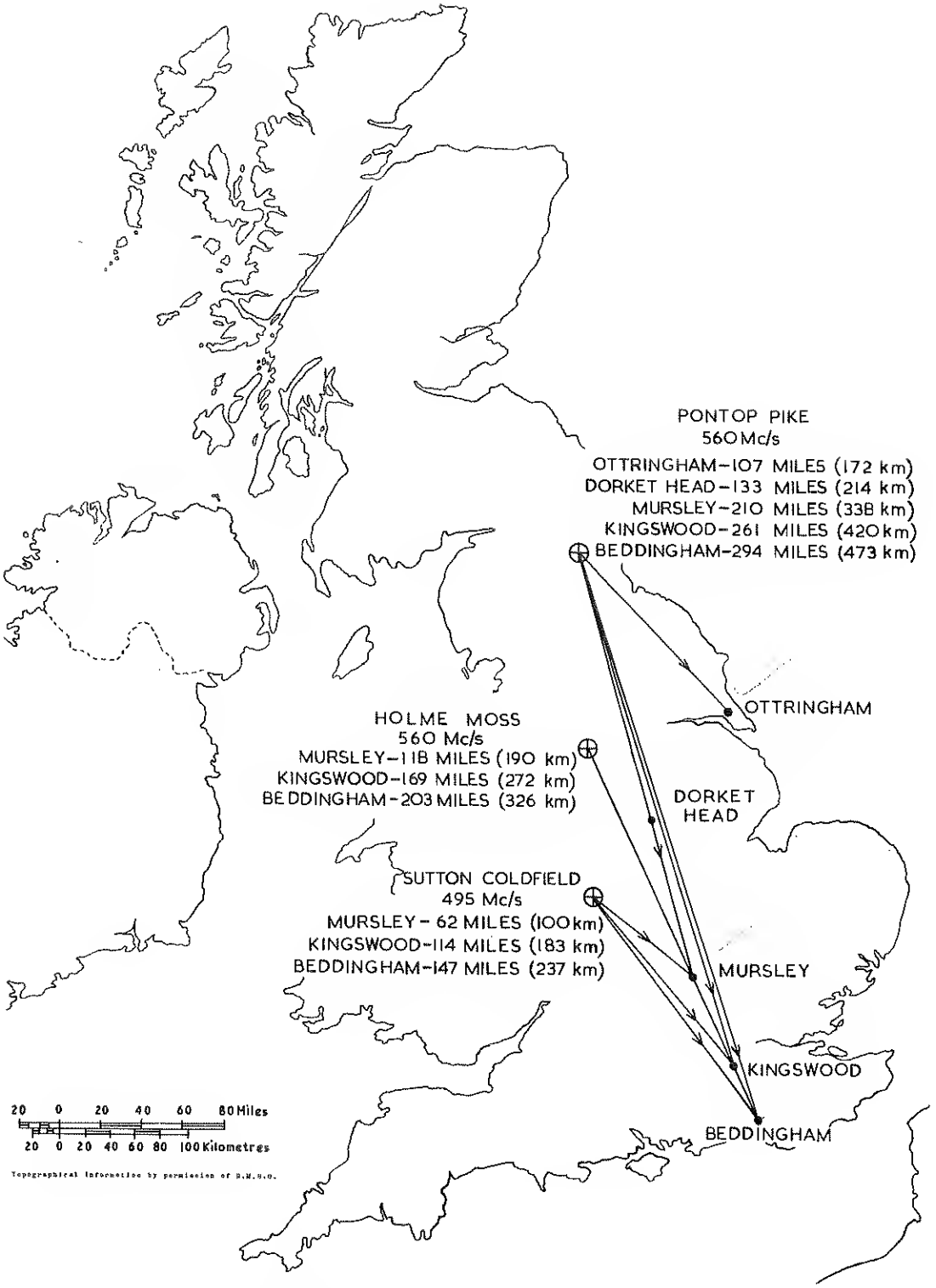


Fig. 1 - Geographical distribution of transmitting and receiving sites

● Receiving sites ⊕ Transmitting sites

Surrey, and Beddingham, near Lewes in Sussex, providing path distances of from 62 miles (100 km) to 203 miles (326 km). The Sutton Coldfield transmissions began in March 1955 and continued to July 1956. The Holme Moss transmissions began in July 1955 and continued to November 1956 and the transmitter was then moved to Pontop Pike to extend the range of distances from 107 miles (172 km) to 294 miles (473 km), two further receiving sites being added, one at Ottringham and another at Dorket Head, Nottingham. The Pontop Pike transmissions began in January 1957 and continued to June 1958.

Fig. 1 shows the geographical distribution of the transmitting and receiving sites.

3. APPARATUS AND SITES

3.1. Transmitters

The transmitters were designed for operation in Band IV. The transmitter at Holme Moss, later installed at Pontop Pike, operated on a carrier frequency of 560 Mc/s and the transmitter at Sutton Coldfield used 495 Mc/s. The transmissions were 100% "square-wave" modulated at 1000 c/s and were cut automatically for 2 seconds every minute so that the signals could be identified at the receiving sites. Six-element Yagi aerials were used for transmitting.

Details of the transmitting sites are given in Table 1.

TABLE 1

Station	Freq.	Period of Measurements	Maximum E.R.P.	Site Height a.m.s.l.		Aerial Height a.g.l.		Latitude	Longitude	Aerial Polarization	Direction of Maximum Radiation
	Mc/s		Watts	ft	m	ft	m				
Sutton Coldfield	495	Mar. 1955 to July 1956	400	555	169	594	181	52°35'59"N	01°49'57"W	H	143°
Holme Moss	560	July 1955 to Nov. 1956	350	1720	524	594	181	53°31'58"N	01°51'22"W	H	156°
Pontop Pike	560	Jan. 1957 to June 1958	800	1002	305	410	125	54°52'08"N	01°46'11"W	H	164°

3.2. Receivers and Sites

The type of receiver used for these experiments was described in detail in an earlier Research Department report.[6] The main features of the receiver are its high sensitivity and stability of calibration. A high output signal/noise ratio is

achieved by using 1000 c/s modulation at the transmitter and restricting the bandwidth of the receiver circuits following the detector.

Full receiving site details are given in Table 2.

TABLE 2

Receiving Station	Transmitting Station	Distance of Receiving Site from Transmitter		Site Height a.m.s.l.		Aerial Height a.g.l.		Bearing of Site from Trans-mitter	Latitude	Longitude
		miles	km	ft	m	ft	m			
Mursley	Sutton Coldfield	62	100	520	158	30	9·1	135°	51°57'12"N	00°48'05"W
Kingswood	"	114	183	550	167	30	9·1	142°	51°17'20"N	00°12'50"W
Beddingham	"	147	237	600	183	30	9·1	146°	50°50'02"N	00°04'15"E
Mursley	Holme Moss	116	190	520	158	30	9·1	158°	51°57'12"N	00°48'05"W
Kingswood	"	169	272	550	167	30	9·1	155°	51°17'20"N	00°12'50"W
Beddingham	"	203	326	600	183	30	9·1	156°	50°50'02"N	00°04'15"E
Ottringham	Pontop Pike	107	172	30	9·1	30	9·1	139°	53°41'50"N	00°03'52"W
Dorket Head	"	133	214	460	140	30	9·1	169°	53°01'02"N	01°06'48"W
Mursley	"	210	338	520	158	30	9·1	169°	51°57'12"N	00°48'05"W
Kingswood	"	261	420	550	167	30	9·1	165°	51°17'20"N	00°12'50"W
Beddingham	"	294	473	600	183	30	9·1	164°	50°50'02"N	00°04'15"E

4. RESULTS

4.1. Analysis

The transmitters radiated from 0900–2300 hours daily. The recording charts were run at speeds of 3 in. (7·6 cm) or 6 in. (15·2 cm) per hour depending on the type of fading normally received.

The daily recording was split into two periods, 0900–1800 hours and 1800–2300 hours, in order to give an indication of any diurnal change of signal strength. The daily analysis was grouped into months and finally the months were grouped to give the overall results.

The analysis consisted of determining the time duration during which a signal was received exceeding each of several fixed levels of field strength. These time durations, expressed as a percentage of the overall valid recording time, were plotted against the signal level, separate graphs being prepared for each transmission path. The field strength exceeded for any required percentage of the overall time was then plotted against each of the distances at which the recordings were made and a family of curves was then constructed showing field strength against distance for 0.1%, 1.0%, 10% and 50% of the overall time.

4.2. Receiving Site Variation Factor

The receiving sites chosen are often not representative of average reception in the areas surrounding them. They may, as in the case of Beddingham, be sited on a hill dominating the surrounding area and may therefore receive a much greater field strength than the majority of domestic receiving installations in that area.

To relate the field strength as measured at a given site to the average field strength for the surrounding area, a correction factor has to be applied to the measured results. This factor is known as the "site variation factor" (s.v.f.). An approximate estimate of the s.v.f. was obtained by choosing 15–20 sites within a 5-mile (8-km) radius of the fixed receiving site and comparing the measured field at each of these sites with that at the fixed site. The ratio in decibels of the field strength at each of the temporary sites to that at the fixed site was found and the mean of the ratios for all the sites was taken as the site variation factor. A negative s.v.f. indicates that the fixed site is superior to the average for the area.

The results of the s.v.f. measurements made during the experiments are tabulated in the Appendix. These were obtained for three paths only, Sutton Coldfield to Mursley, Holme Moss to Mursley, Pontop Pike to Ottringham. Signals were too weak for measurements to be made at the other receiving sites except during abnormal propagation conditions.

Table 3gives the s.v.f. for each receiving site as measured on the different transmissions. Measurements of s.v.f. were made at Mursley on two transmissions and it will be seen that there is a difference of 5·5 dB. This difference may be due to significant differences in ground profiles between the receiving site and the two transmitters.

TABLE 3

Measured Site Variations Factors

Transmitter	Receiving Site	Site Variation Factor (s.v.f.) dB
Sutton Coldfield	Mursley	−13·0
Holme Moss	Mursley	−7·5
Pontop Pike	Ottringham	−2·5

The results of the measurements made to obtain the s.v.f. for the three receiving sites are tabulated in the Appendix and are plotted in Fig. 2 with the ordinate scale normalised to show the field strength relative to the median value with respect to location. An example of the use of Fig. 2 indicates that, since the s.v.f. for Mursley (Sutton Coldfield) is −13 dB, it will be seen from curve (a) that 92% of locations around Mursley receive a lower field strength from Sutton Coldfield than is received at the site used for the long term recording of the tropospheric signals.

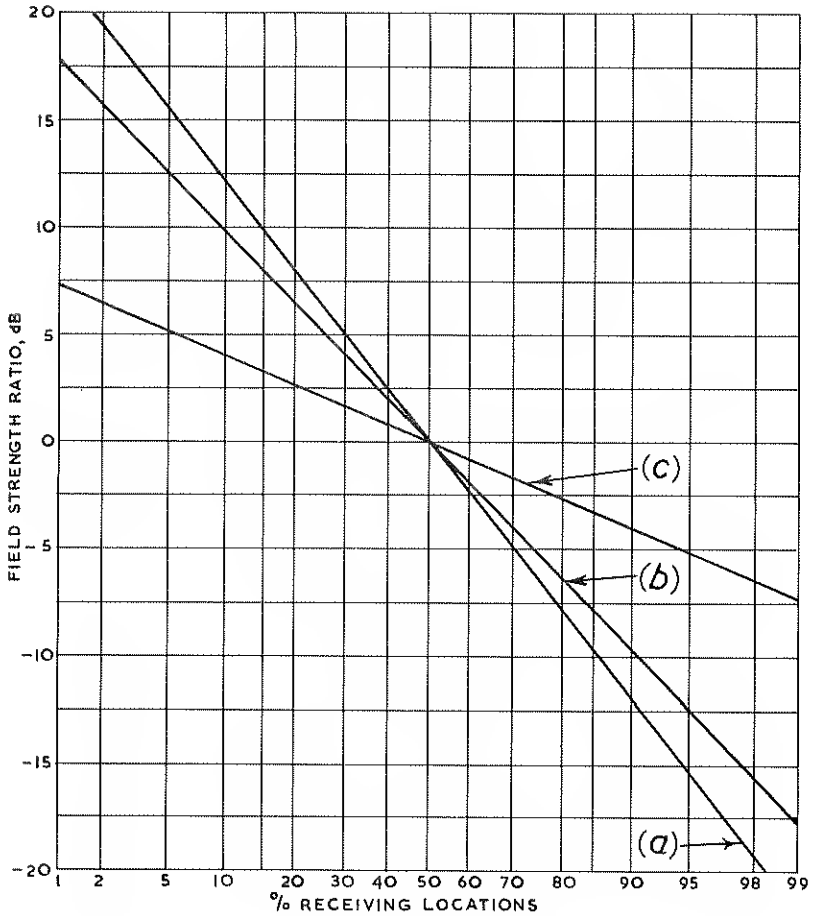


Fig. 2 - Field strength ratio in dB related to number of receiving sites (per cent)

(a) Mursley - Sutton Coldfield (495 Mc/s)
(b) Mursley - Holme Moss (560 Mc/s)
(c) Ottringham - Pontop Pike (560 Mc/s)

TABLE 4

Estimated Site Variation Factors

Transmitter	Receiving Site	Assumed Site Variation Factor (s.v.f.) dB
Sutton Coldfield	Kingswood	+5·5
"	Beddingham	-13·5
Pontop Pike	Dorket Head	-1·5
"	Mursley	-10·0
"	Kingswood	+5·5
"	Beddingham	-13·5
Holme Moss	Kingswood	+5·5
"	Beddingham	-13·5

The s.v.f. measurements made at the time of the Band III long distance overland measurements experiment[5] have been assumed to apply to those receiving sites where measurements of s.v.f. were not made on Band IV. An exception is Mursley (Pontop Pike) where the approximate average of Mursley (Sutton Coldfield) and Mursley (Holme Moss) was assumed. The Band III s.v.f.s measured at Kingswood and Beddingham on the Sutton Coldfield transmissions were assumed to apply to the Holme Moss and Pontop Pike paths. These estimated s.v.f.s are given in Table 4.

4.3. Sutton Coldfield Transmissions

The Sutton Coldfield u.h.f. transmissions started in March 1955 and continued until July 1957. The three receiving sites were not all operational for the full seventeen months. Measurements were begun at each site as soon as the receiving equipment became available. They started at Mursley and Beddingham in July 1955 and November 1955 respectively and Kingswood was operational for the full period.

Fig. 3 shows the results of the analysis of the measurements made at Mursley, Kingswood and Beddingham. The field strength values have been corrected for a radiated power of 1 kW from a half-wave dipole. Tabulated results, appropriate to certain fixed percentage times and with and without correction by the s.v.f., are given in Table 5.

Signals were received at Kingswood for just over 1% of the total recording time and at Beddingham for about 7% of the total recording time.

Curves (b) and (c) in Fig. 3 were extrapolated to obtain the values for 10% of the time given in Table 5, which may therefore be subject to some error.

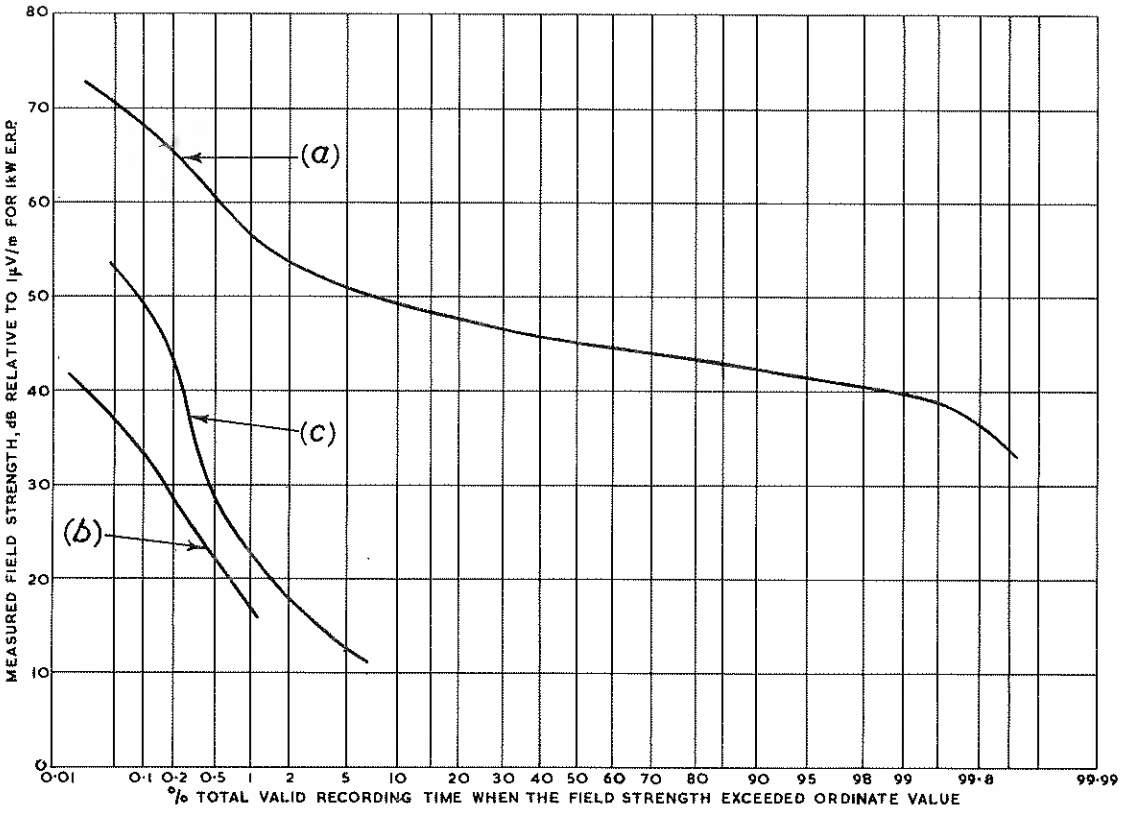
The receiving site at Mursley is 62 miles (100 km) from Sutton Coldfield and the signal received there during normal propagation conditions showed only slight variation of signal level from day to day. During periods of abnormal propagation, however, the field strength showed slow fading characteristics with occasional "drop-outs" to 30 dB or more below normal level for periods of a few minutes.

Signals were not received at Kingswood and Beddingham during normal propagation conditions, but during periods of abnormal propagation the signals rose above noise level with slow fading characteristics.

It is of interest to note from Fig. 3 that the free space field at Mursley, 67 dB relative to 1 μV/m for an e.r.p. of 1 kW, was exceeded for approximately 0·13% of the total time.

4.4. Holme Moss Transmissions

The Holme Moss transmissions began in July 1955 and continued until November 1956. The receiving sites at Mursley and Kingswood were in operation from the start of the transmissions and measurements were started at Beddingham in November 1955. Fig. 4 shows the results of the analysis of the measurements made at Mursley, Kingswood and Beddingham plotted as field strength against percentage time. The tabulated results, appropriate to certain fixed percentage times, with and without s.v.f. corrections, are given in Table 6.



Curve	Receiver	Distance		Total Hours Recorded	Free* Space Field
		ml	km		
(a)	Mursley	62	100	3143	66·9
(b)	Kingswood	114	183	4652	61·6
(c)	Beddingham	147	237	2481	59·4

*dB rel. 1 μV/m for 1 kW E.R.P.

Fig. 3 - Sutton Coldfield transmission (495 Mc/s) - variation of field strength with time

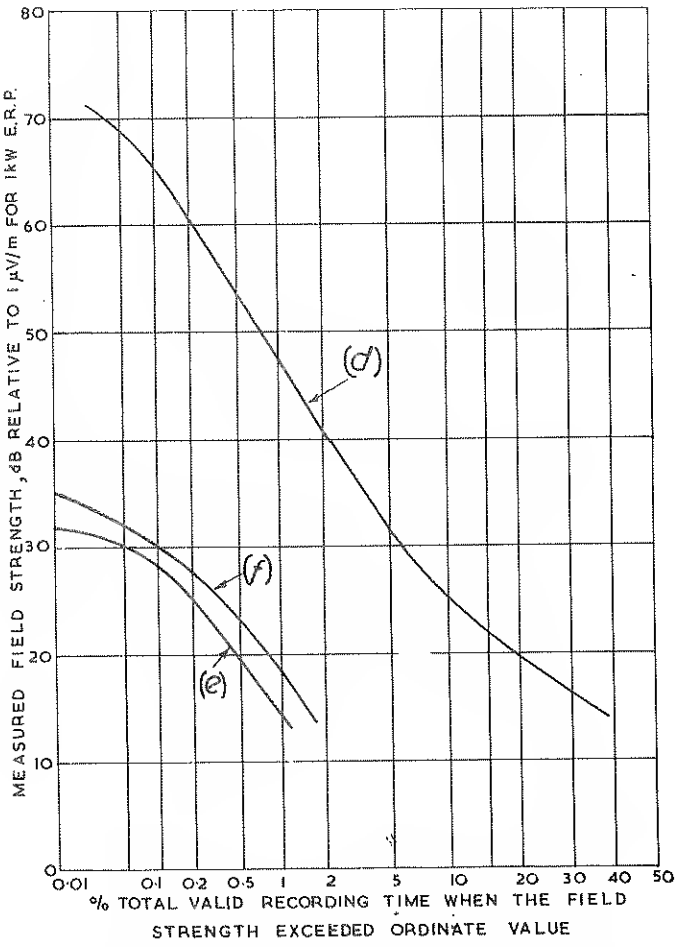
TABLE 5

Sutton Coldfield Results - 495 Mc/s

Curve	Receiving Site	Measured Field Strength (dB rel. 1μV/m for 1 kW e.r.p.)							Field Strength corrected for s.v.f. (dB rel. 1μV/m for 1 kW e.r.p.)						
		0·1%	1·0%	10%	50%	90%	99%	99·9%	0·1%	1·0%	10%	50%	90%	99%	99·9%
(a)	Mursley	68·0	56·5	49·5	45·0	42·0	39·5	34·0	55·0	43·5	36·5	32·0	29·0	26·5	21·0
(b)	Kingswood	33·5	17·0	-3·0*	N	N	N	N	39·0	22·5	2·5*	N	N	N	N
(c)	Beddingham	49·5	23·0	9·0*	N	N	N	N	36·0	9·5	-4·5*	N	N	N	N

*Extrapolated values

N - Signals below noise level at recording site



Curve	Receiver	Distance		Total Hours Recorded	Free* Space Field
		ml	km		
(d)	Mursley	118	190	4146	61·3
(e)	Kingswood	169	272	4568	58·2
(f)	Beddingham	203	326	3765	56·6

*dB rel. 1 μV/m for 1 kW E.R.P.

Fig. 4 - Holme Moss transmission (560 Mc/s) - variation of field strength with time

The s.v.f. was measured at Mursley. Measurements of s.v.f. during the Band III experiment for the Sutton Coldfield transmission were assumed to be applicable to Kingswood and Beddingham. The curves in Fig. 4 were extrapolated to record values for 10% of the total recording time at Kingswood and Beddingham, and the 50% value for Mursley.

The signals received at Mursley were of the fast fading type during periods of low field strength, changing to a slow fading rate during periods of high field strength. The free space field was exceeded for approximately 0·17% of the total time.

TABLE 6

Holme Moss Results – 560 Mc/s

Curve	Receiving Site	Measured Field Strength (dB rel. 1 μV/m for 1 kW e.r.p.)				Field Strength corrected for s.v.f. (dB rel. 1 μV/m for 1 kW e.r.p.)			
		0·1%	1·0%	10%	50%	0·1%	1·0%	10%	50%
(d)	Mursley	65·0	47·0	24·5	11·0*	57·5	39·5	17·0	3·5*
(e)	Kingswood	28·5	14·0	-5·0*	N	34·0	19·5	0·5*	N
(f)	Beddingham	30·0	18·5	-6·0*	N	16·5	5·0	-19·5*	N

*Extrapolated values

N – Signals below noise level at recording site

Signals were received at Kingswood and Beddingham only during periods of abnormal propagation and had slow fading characteristics.

4.5. Pontop Pike Transmissions

As stated earlier, the transmission path was extended by transferring the Holme Moss transmitter to Pontop Pike. The receiving sites at Mursley, Kingswood and Beddingham were retained and additional sites at Dorket Head (Nottingham) and Ottringham, near Hull, were commissioned. Transmissions started in January 1957 and continued until June 1958. Measurements were continuous at Ottringham, Mursley and Beddingham over the full period but there was a break in the measurements at Dorket Head during May and June 1957 and the Kingswood measurements ceased in January 1958.

The analysed results of measurements taken at the receiving sites have been plotted in Fig. 5 which shows the levels exceeded for given percentages of the time. Table 7 is a tabulated list of measurements with and without correction for s.v.f. for various percentages of the overall time.

During periods of abnormal propagation the signals received had slow fading characteristics. Signals were only received at Kingswood and Beddingham under exceptionally good propagation conditions. Weak, fast fading signals were occasionally received at Dorket Head and Mursley and signals were received at Ottringham for a considerable proportion of the time.

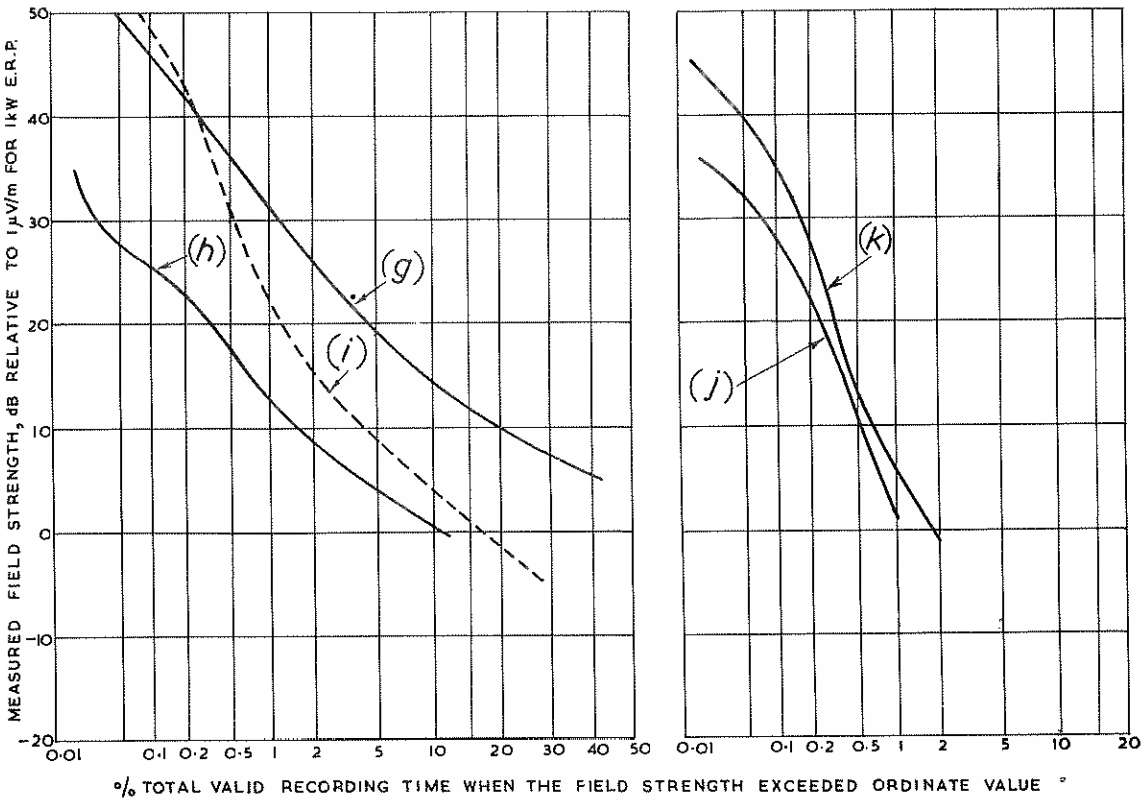
TABLE 7

Pontop Pike Results – 560 Mc/s

Curve	Receiving Site	Measured Field Strength (dB rel. 1 μV/m for 1 kW e.r.p.)				Field Strength corrected for s.v.f. (dB rel. 1 μV/m for 1 kW e.r.p.)			
		0·1%	1·0%	10%	50%	0·1%	1·0%	10%	50%
(g)	Ottringham	45·5	31·0	14·5	3·5*	43·0	28·5	12·0	1·0*
(h)	Dorket Head	25·5	12·5	0·5	-9·0*	24·0	11·0	-1·0	-10·5*
(i)	Mursley	47·5	21·5	4·0	-12·0*	37·5	11·5	-6·0	-22·0*
(j)	Kingswood	28·0	0·5	-25·0*	N	33·5	6·0	-19·5*	N
(k)	Beddingham	35·0	5·5	-20·0*	N	21·5	-8·0	-33·5*	N

*Extrapolated values

N – Signals below noise level at recording site



Curve	Receiver	Distance		Total Hours Recorded	Free* Space Field
		ml	km		
(g)	Ottringham	107	172	6169	62·2
(h)	Dorket Head	133	214	5884	60·3
(i)	Mursley	210	338	5367	56·3
(j)	Kingswood	261	420	3545	54·4
(k)	Beddingham	294	473	6313	53·4

*dB rel. 1 μV/m for 1 kW E.R.P.

Fig. 5 - Pontop Pike transmission (560 Mc/s) - variation of field strength with time

It is of interest to note that the measured results (Fig. 5) gave a higher field strength for Mursley than for Dorket Head and in fact the free space field was occasionally exceeded at Mursley. After applying the assumed s.v.f.s quoted in Section 4.2, the Mursley 0·1% figure is still higher (13·5 dB) than that of the Dorket Head figure, while the 1% values are similar. The cause of this phenomenon has not so far been determined.

4.6. Band IV Field Strength/Distance Curves

The measured and extrapolated field strengths listed in Tables 5, 6 and 7 are shown in Fig. 6 plotted against distance for 0·1%, 1%, 10% and 50% of the time.

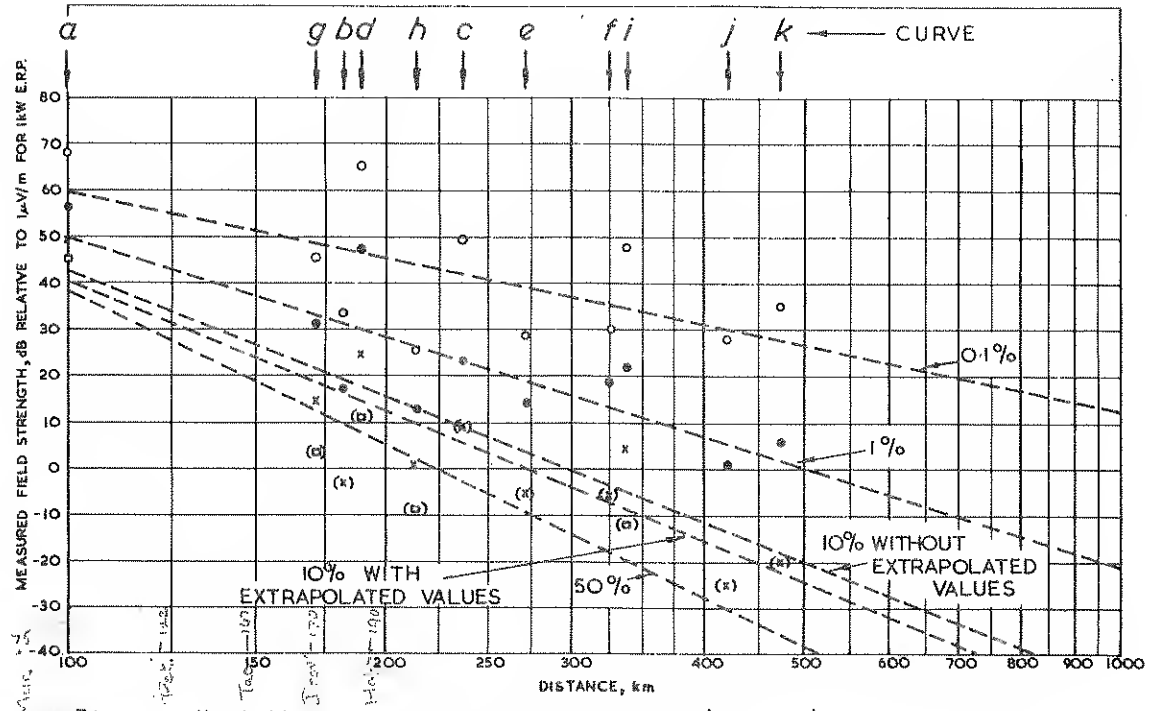


Fig. 6 - Variation of measured field strength (Band IV) with distance for fixed "percentage times"

○ 0·1%, ● 1%, × 10%, □ 50%, ( ) extrapolated field strength

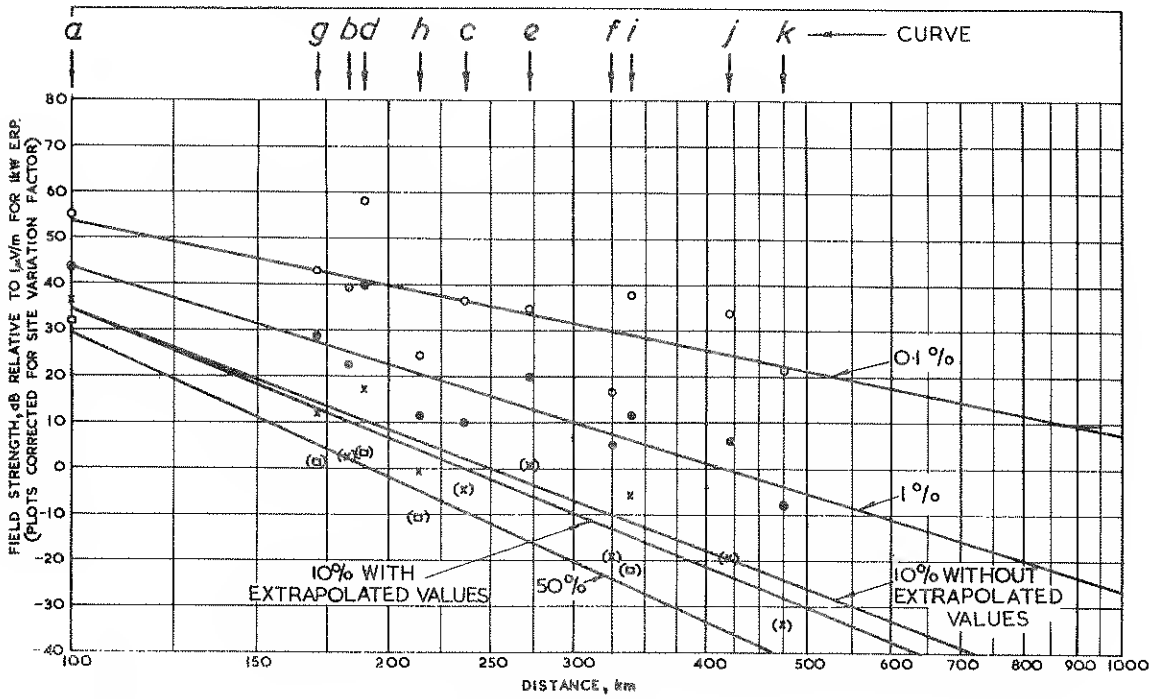


Fig. 7 - Variation of corrected field strength (Band IV) with distance for fixed "percentage times"

○ 0·1%, ● 1%, × 10%, □ 50%, ( ) extrapolated field strength

Lines of "best fit", calculated by the method of least squares for a logarithmic distance scale, are drawn through the points relating to each time percentage value. Two 10% curves are shown, one derived from the five measured values only, and the other including the extrapolated values for Kingswood and Beddingham for all three transmissions. Fig. 7 is the corresponding field strength/distance graph with correction for the s.v.f. included. Again, two 10% curves are shown and the lower curve, which includes the extrapolated values for Kingswood and Beddingham for all three transmissions, is considered to be the more representative one, applying to the average receiving location in any area.

Comparison between Figs. 6 and 7 reveals that the s.v.f. correction gives a field strength/distance curve lower by about 6 dB than the measured values. Although most of these s.v.f.s were assumed to be the same as those measured in the Band III experiment and are thus only approximate values, the scatter of points is reduced by applying the correction.

The fact that a "best fit" straight line can be derived on the logarithmic distance scale implies an inverse power relationship between field strength, E, with distance, d, of the form $E = K/d^n$ where K is a parameter related to the transmission path and to the power of the transmitter. Values of n and 20 log K obtained from the eleven sets of data, corrected for s.v.f., are shown in Table 8. It is interesting to note that the slope of the curve increases in steepness with increasing percentage time, indicating a reduced dependence of the field strength on distance under conditions of abnormal propagation.

TABLE 8

Band IV – Slope of Field Strength/Distance Curves

Percentage Time	n	20 log K
0·1%	−2·31	146
1%	−3·51	184
10%	−4·66	221
50%	−5·19	237

The field strength/distance curves of Fig. 7 are replotted on linear paper in Fig. 8, together with the C.C.I.R. curves adopted at the IXth Plenary Assembly, Los Angeles, 1959, for the frequency range 40–600 Mc/s. The data presented in this report were made available to the C.C.I.R. and used, in conjunction with data available from other countries, to prepare the C.C.I.R. curves. There are significant, even large, differences between the two 10% and 50% curves. These can only be accounted for by the fact that the C.C.I.R. curves are derived from the results of measurements over many transmission paths in several different countries, heavily weighted by a mass of data relating to the frequency bands between 40–600 Mc/s. A future revision of the C.C.I.R. curves, for the u.h.f. spectrum, would be likely to be considerably influenced by the data presented in this report.

4.7. Comparison of Bands III and IV Overland Field Strength/Distance Curves

The field strength/distance curves, corrected for s.v.f. given in this report (Fig. 7) are plotted in Fig. 9 together with the field strength/distance

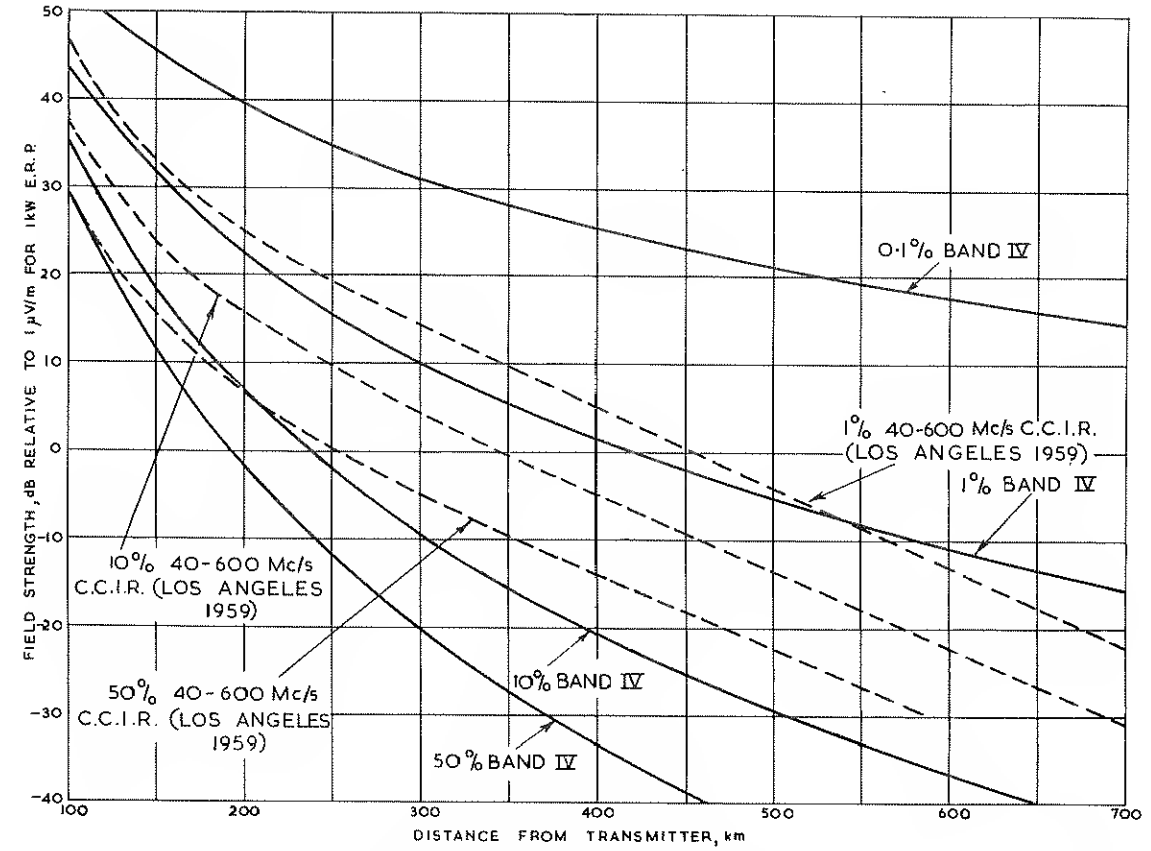


Fig. 8 - Comparison of corrected Band IV with C.C.I.R. (Los Angeles 1959) 40-600 Mc/s field strength/distance curves

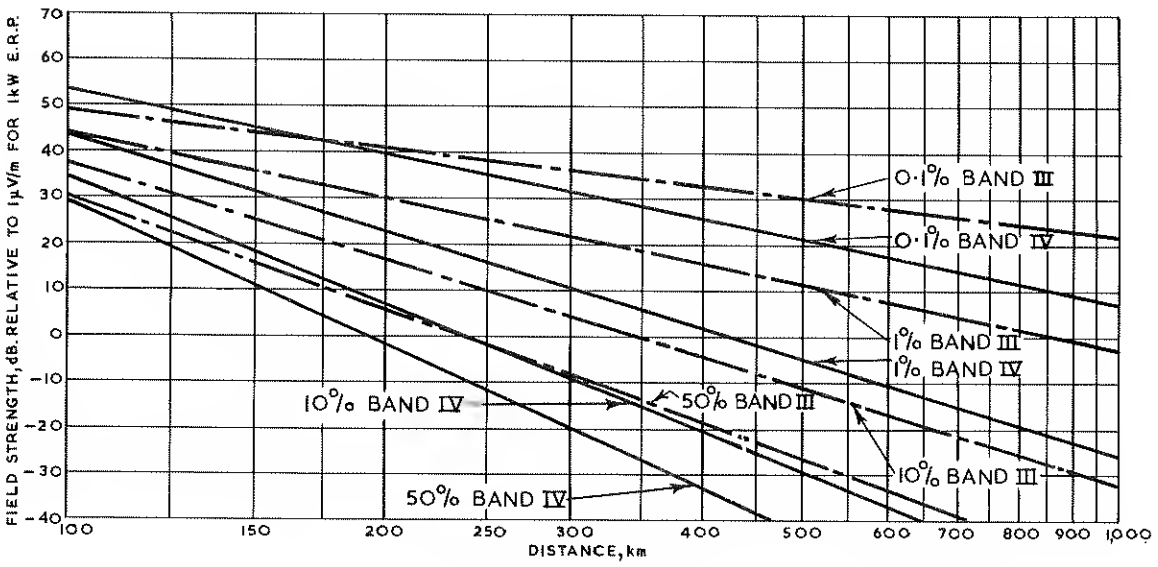


Fig. 9 - Comparison of Bands III and IV field strengths against distance

curves obtained from the Band III experiment.[5] It will be seen that, except for distances from 100 km to 170 km in the 0·1% case only, the Band III curves show less attenuation than the Band IV curves, indicating a dependence of field strength on frequency at great distances. For example, the difference between the field strength exceeded for 10% of the time at 400 km is 16 dB.

The transmission paths and the period of the measurements were not identical in these two experiments. Measurements were made on both Band III and Band IV transmissions from Pontop Pike from January 1957 to February 1958. The measured field strengths are tabulated in Table 9.

TABLE 9

Comparison of Bands III and IV Transmissions
from Pontop Pike

Receiving Site	Band	Total Hours Recorded	Measured Field Strength (dB rel. 1μV/m for 1 kW e.r.p.)			
			0·1%	1%	10%	50%
Ottringham	III	4253	42·5	31·5	18·5	6·5
	IV	4572	47·0	33·0	15·5	4·5
Dorket Head	III	3798	38·0	26·0	12·0	N
	IV	4085	26·5	14·5	2·0	N
Mursley	III	4210	43·0	29·5	11·0	N
	IV	3837	50·0	26·5	5·5	N
Kingswood	III	3197	31·0	11·0	N	N
	IV	3545	28·0	0·5	N	N
Beddingham	III	4157	42·0	20·0	N	N
	IV	4517	37·0	8·0	N	N

N – Signals below noise level at recording site

Lines of "best fit" are drawn in Fig. 10 for the Band III and Band IV 0·1%, 1% and 10% measurements given in Table 9. It will be seen from Fig. 10 that there is little difference between Bands III and IV for the 0·1% curves but that there is a significant difference in the case of the 1% and 10% curves at the greater distances. This is an indication that the field strength is less dependent on frequency under extreme conditions of abnormal propagation. Fig. 11 shows the results of the analysis of the simultaneous records made at Mursley on Pontop Pike Bands III and IV transmissions over exactly the same period of time. This figure shows frequency dependence effects varying with the percentage of time.

4.8. Monthly Field Strength Variations

The field strengths exceeded in each month for each percentage time are plotted in Figs. 12, 13 and 14 for the transmission paths of Sutton Coldfield, Holme Moss and Pontop Pike respectively.

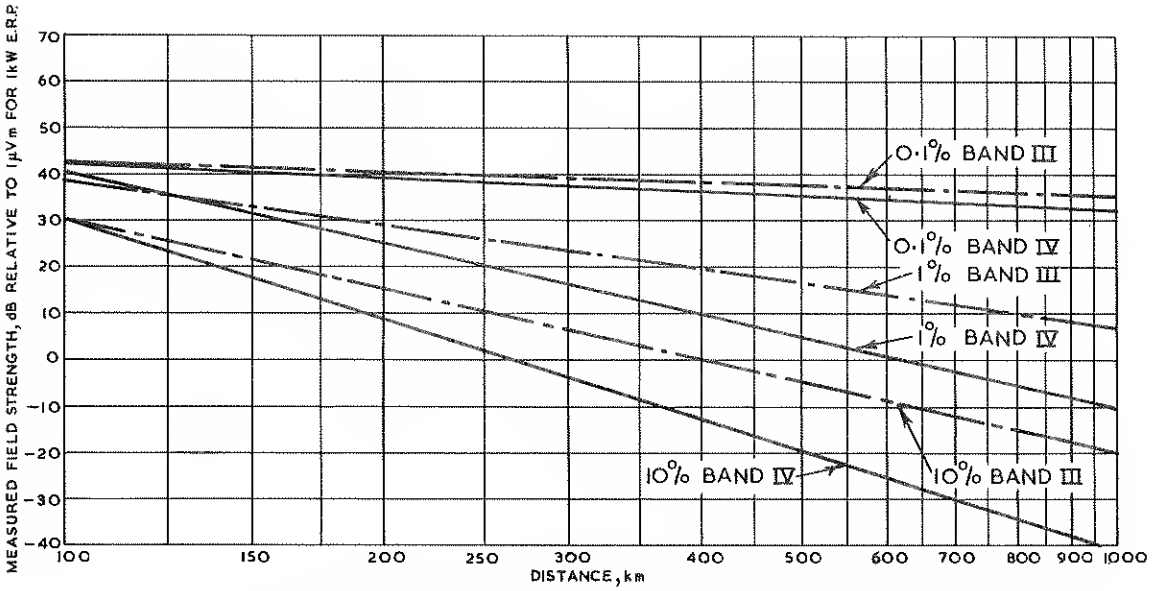


Fig. 10 - Comparison of Bands III and IV (Pontop Pike) measured field strengths against distance

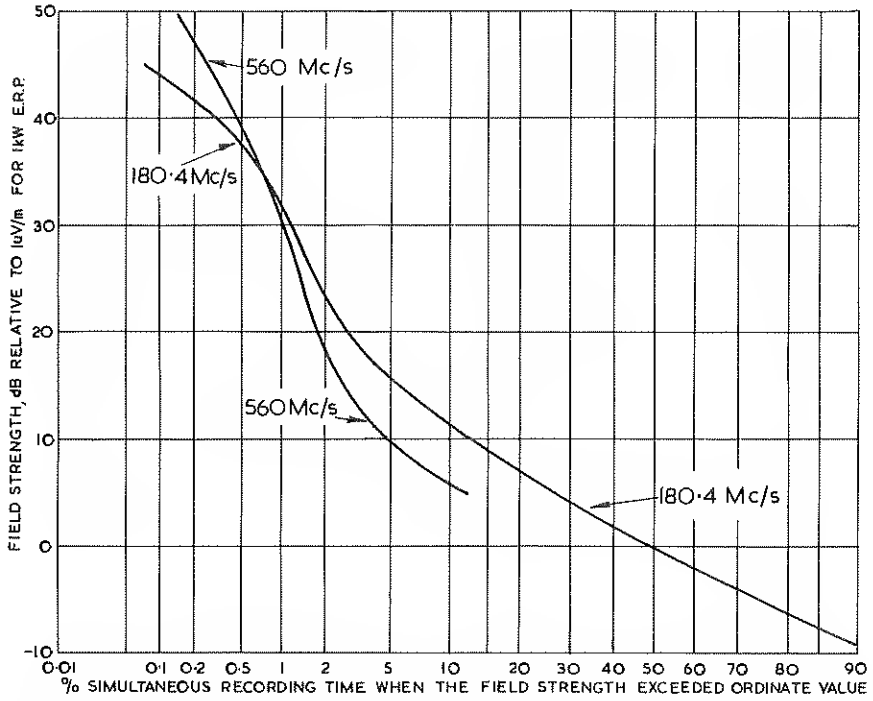


Fig. 11 - Comparison of the simultaneous recordings made at Mursley on Bands III and IV transmissions from Pontop Pike - variation of field strength with time

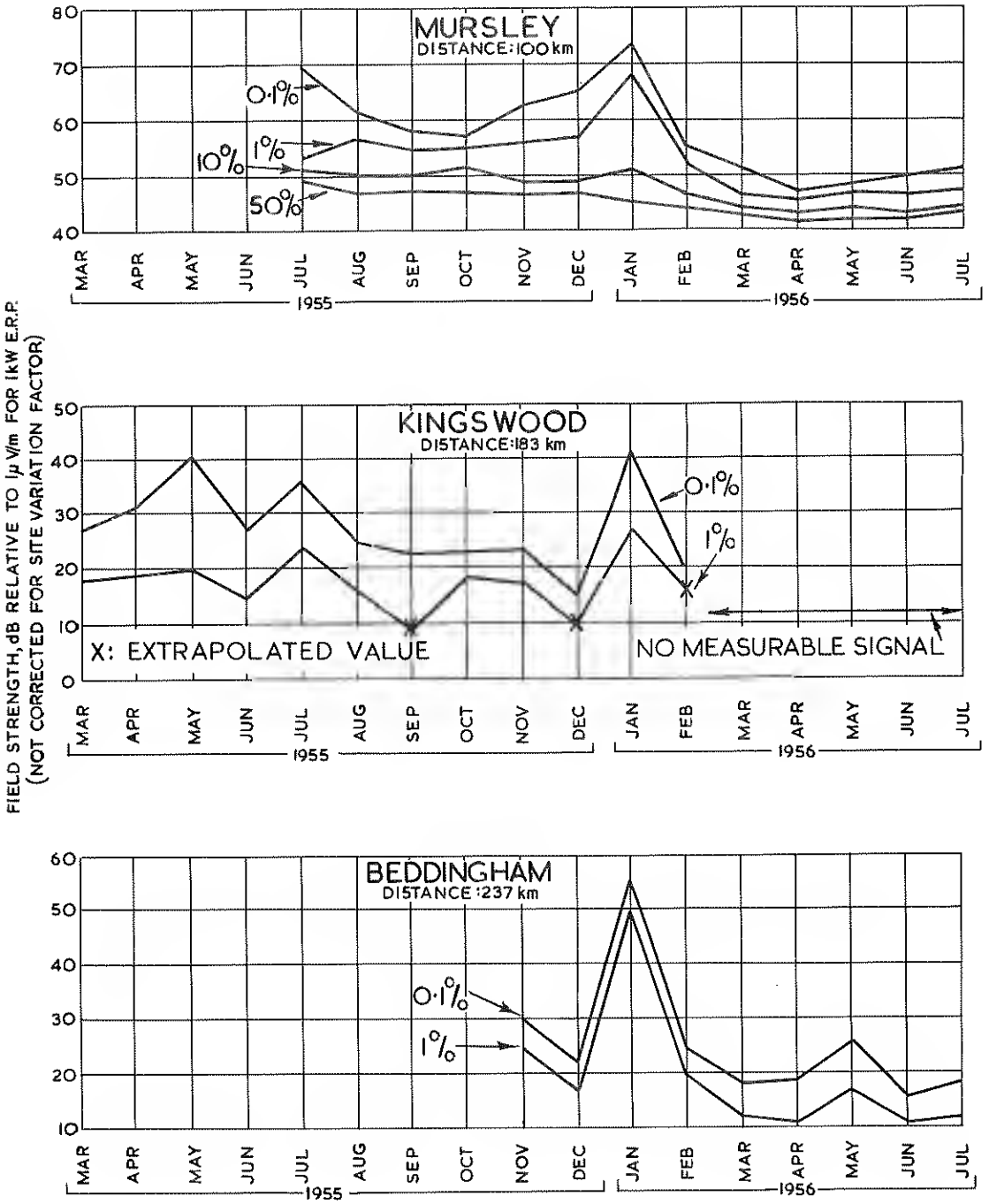


Fig. 12 - Band IV (495 Mc/s) - Sutton Coldfield transmission. Field strengths exceeded in each month for 0·1%, 1%, 10% and 50% of the time

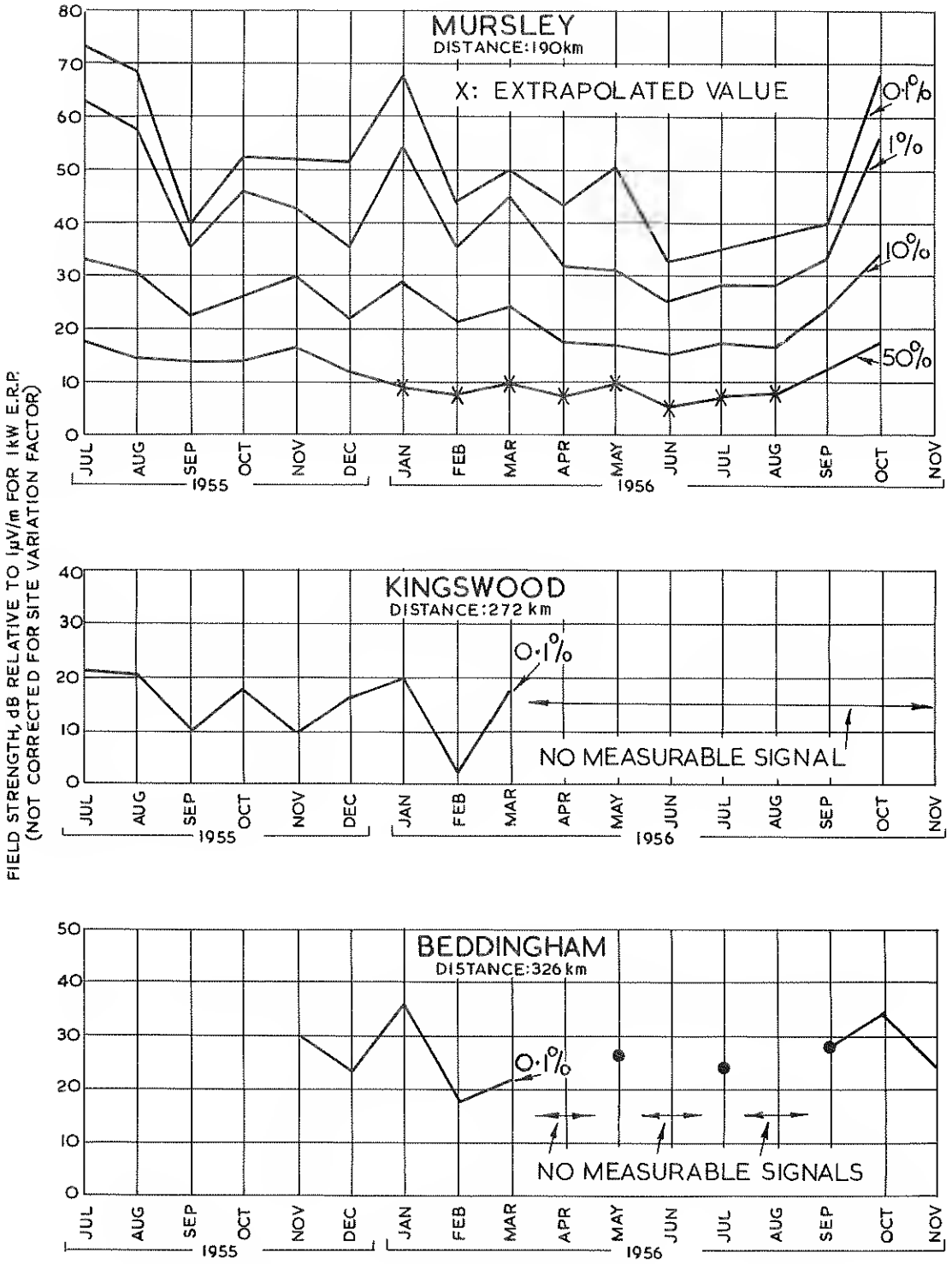


Fig. 13 - Band IV (560 Mc/s) - Holme Moss transmission. Field strengths exceeded in each month for 0·1%, 1%, 10% and 50% of the time

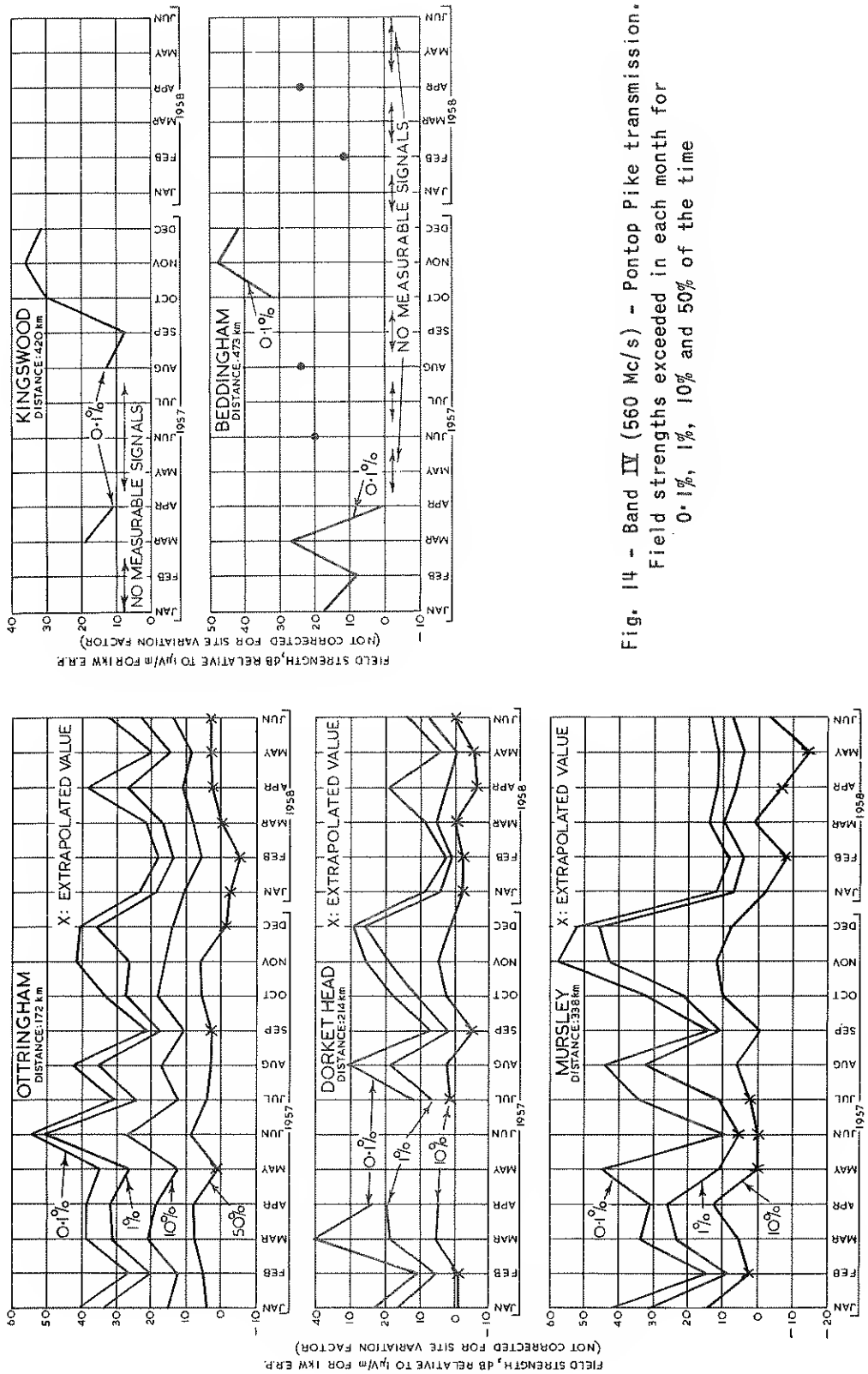


Fig. 14 - Band IV (560 Mc/s) - Pontop Pike transmission.
Field strengths exceeded in each month for
0·1%, 1%, 10% and 50% of the time

Measurements were not made at all sites throughout the full period of transmissions from Sutton Coldfield and Holme Moss and no significant seasonal trend can be discerned from Figs. 12 and 13. High field strengths occurred at all sites during January 1956, but occurred also at all sites where measurements were made in July 1955.

Features worth noting in Figs. 12, 13 and 14 are that the month to month variations in field strength increase with increasing distance and with decreasing percentage times. These points are more clearly demonstrated in Fig. 15, where the standard deviations of the field strength values in Figs. 12, 13 and 14 are plotted as a function of distance for each percentage time where monthly measurements were obtained. The lines of "best fit" drawn show that the month to month variations increase with distance in the case of the 0·1% and 1% values.

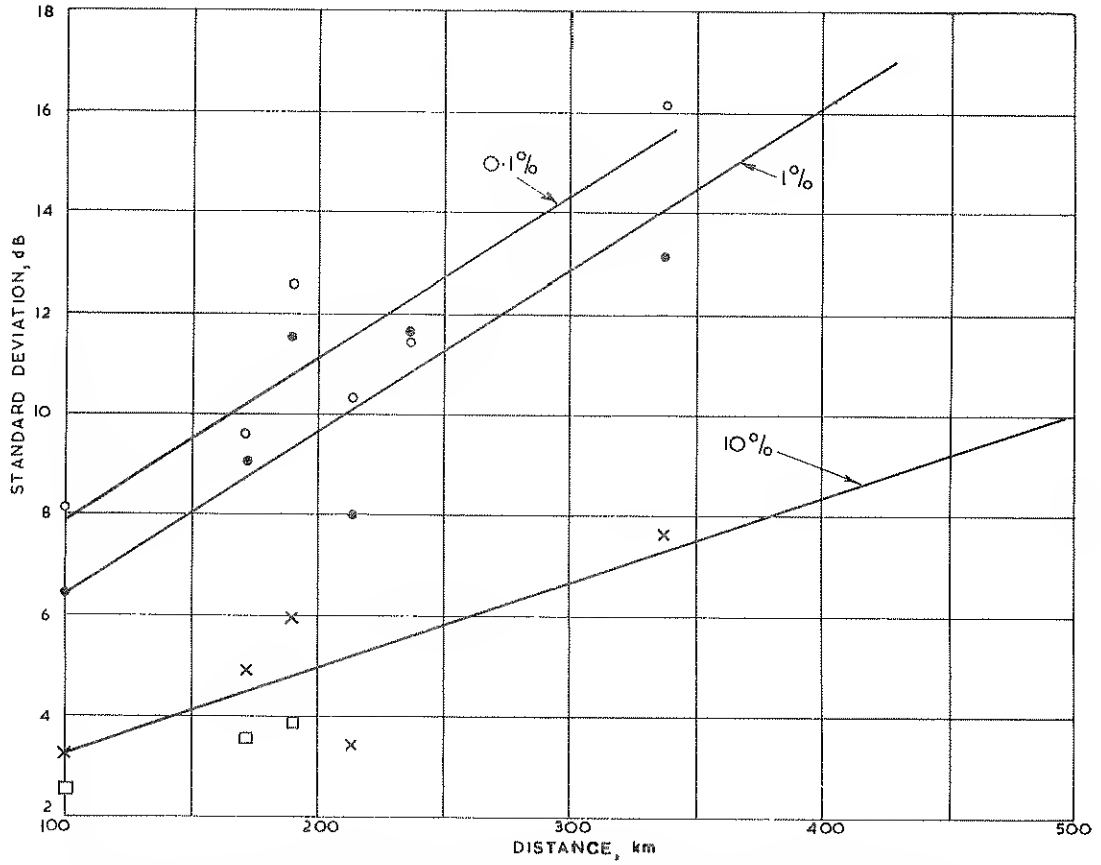


Fig. 15 - Standard deviation of the field strengths exceeded in each month for different percentage times plotted against distance

○ 0·1%, ● 1%, × 10%, □ 50%

The large standard deviations at the greater distances for the 0·1% and 1% field strengths emphasise the need for continuing the type of experiment discussed in this report for periods long enough to embrace the whole range of tropospheric variations if reliable figures of field strength for the small percentage time values are to be obtained.

5. CONCLUSIONS

The investigations described in this report were conducted over land paths on frequencies in Band IV. The gradients of the field strength/distance curves derived from the measurements decrease with decreasing percentage times, implying a decreasing influence of distance on the received field strength under abnormal conditions.

Comparison between the field strength/distance curves derived from the measurements in this report and the Band III report[5] indicate that the Band III range of frequencies is propagated, for the greater proportion of the time, with less attenuation than the frequencies in Band IV at the greater distances.

Comparisons made between measurements on the 180·4 Mc/s and 560 Mc/s transmissions from Pontop Pike over the same period of time and over the same paths show a dependence of attenuation on frequency for the "1%" and "10%" field strength/distance curves which increases with distance. There is little difference between the "0·1%" curves, implying a decreasing influence of frequency on the received field strength under conditions of high abnormal propagation.

The field strength exceeded for each month for the various percentage times varies over a greater range as the percentage time decreases. Variations of the "0·1%" and "1%" field strengths also increase with increasing distances.

6. ACKNOWLEDGEMENTS

The B.B.C. acknowledges with thanks the assistance given by the following authorities, who provided sites and facilities: Buckingham County Constabulary, East Sussex County Constabulary, and Rediffusion (East Midlands) Ltd.

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APPENDIX

SITE VARIATION FACTOR MEASUREMENTS

SITE VARIATION FACTOR – MEASUREMENTS MADE IN MURSLEY AREA

TRANSMISSION FROM SUTTON COLDFIELD – BAND IV (560 Mc/s)

Test No.	Site Location	Grid Reference (100 km square SP)	Site Height (a.m.s.l.)		Distance from Fixed Site		Field Strength		Comparison of Field Strength of Temporary with Fixed Site (dB)	Site Details
			ft	m	ml	km	Temporary Site (dB)	Fixed Site (dB)		
1	Oving	786218	500	152	5·0	8·0	43·0	42·0	+1·0	Approaching crest of hill. Concave slope in front. Low wires at roadside. Small trees on left and houses 300 yd at rear.
2	Gt. Horwood Common	777322	420	128	3·5	5·6	40·5	41·5	−1·0	Open site. Low telegraph wires at roadside. No trees within ¼ mile.
3	Soulbury	874268	450	137	3·5	5·6	37·5	41·0	−3·5	Open site. Country generally rising towards Mursley 3 miles in front.
4	East Claydon	736254	400	122	5·9	9·5	39·5	43·5	−4·0	Open field with trees 100 yd at rear.
5	Whaddon	798344	350	107	3·5	5·6	34·0	42·0	−8·0	Open site for 100 yd all round. Land falls away slightly.
6	Gt. Horwood	783312	425	129	3·0	4·8	34·5	42·5	−8·0	No trees within 100 yd. Open country in front with scattered trees.
7	Adstock	737308	370	113	5·5	8·8	30·0	42·0	−12·0	Open site with low farm buildings immediately in front and tall hedgerow at rear.
8	Shenley Church End	831374	270	82	5·0	8·0	29·0	41·0	−12·0	Ground rising for 1 mile. Slight screening by trees.
9	Potash Farm	835278	470	143	1·0	1·6	29·0	41·5	−12·5	Open in front rising to crest of hill on which permanent site is situated, but trees within 200 yd.
10	Thornton	762364	300	91	6·0	9·6	26·0	40·5	−14·5	Open site. Ground falling at shallow angle in front.
11	A.5. North of Bletchley	872348	250	76	4·5	7·2	23·5	41·0	−17·5	Open site beside main road. Telephone wires 60 ft in front.
12	Liscombe Park	883252	400	122	4·4	7·1	23·5	41·5	−18·0	Open site but thick trees 400 yd in front.
13	Stoke Hammond	875297	320	97	3·3	5·3	23·0	42·0	−19·0	Open ground in front. No large trees within 150 yd.
14	Winslow–Bennetts Hill	779265	305	93	3·3	5·3	18·5	42·5	−24·0	Site in valley.
15	Cublington	832214	330	100	4·7	7·6	16·0	41·5	−25·5	Site in valley. Some trees on ridge 1½–2 miles in front.
16	Newton Longville	839316	350	107	1·7	2·7	16·0	42·0	−26·0	Clear of trees for 200 yd but hill 2 miles in front.
Fixed Site	Mursley	825291	520	128	–	–	Site Variation Factor −13·0 dB			Open site at crest of gradually sloping terrain.

(Field strengths are expressed in dB relative to 1 μV/m for 1 kW E.R.P.)

SITE VARIATION FACTOR – MEASUREMENTS MADE IN MURSLEY AREA

TRANSMISSION FROM HOLME MOSS – BAND IV (560 Mc/s)

Test No.	Site Location	Grid Reference (100 km square SP)	Site Height (a.m.s.l.)		Distance from Fixed Site		Field Strength		Comparison of Field Strength of Temporary with Fixed Site (dB)	Site Details
			ft	m	ml	km	Temporary Site (dB)	Fixed Site (dB)		
1	Gt. Horwood Common	777322	420	128	3·5	5·6	12·0	9·5	+2·5	Open site. Low telegraph wires at roadside. No trees within ¼ mile.
2	Oving	786218	500	152	5·0	8·0	21·0	19·0	+2·0	Approaching crest of hill. Concave slope in front. Low wires at roadside. Small trees on left and houses 300 yd at rear.
3	Soulbury	874268	450	137	3·5	5·6	9·0	9·0	0	Open site. Country generally rising towards Mursley 3 miles in front.
4	Whaddon	798344	350	107	3·5	5·6	19·0	20·5	−1·5	Open site for 100 yd all round. Land falls away slightly.
5	Stoke Hammond	875297	320	97	3·3	5·3	14·0	15·5	−1·5	Open ground in front. No large trees within 150 yd.
6	Potash Farm	835278	470	143	1·0	1·6	9·0	12·0	−3·0	Open in front rising to crest of hill on which permanent site is situated, but trees within 200 yd.
7	Newton Longville	856312	340	104	2·2	3·5	9·5	13·0	−3·5	Clear of trees for 200 yd but hill 450 ft 3 miles in front.
8	Shenley Church End	831374	270	82	5·0	8·0	25·5	33·0	−7·5	Ground rising for 1 mile. Slight screening by trees.
9	Liscombe Park	883252	400	122	4·4	7·1	8·5	18·0	−9·5	Open site but thick trees 400 yd in front.
10	East Claydon	736254	400	122	5·9	9·5	15·0	25·0	−10·0	Open field with trees 100 yd at rear.
11	Adstock	737908	370	113	5·5	8·8	13·5	26·0	−12·5	Open site with low farm buildings immediately in front and tall hedgerow at rear.
12	Gt. Horwood	783312	425	129	3·0	4·8	19·5	32·5	−13·0	No trees within 100 yd. Open country in front with scattered trees.
13	Winslow–Bennetts Hill	779265	305	93	3·3	5·3	8·5	21·5	−13·0	Site in valley.
14	Cublington	832214	330	100	4·7	7·6	9·5	24·0	−14·5	Site in valley. Some trees on ridge 1½–2 miles in front.
15	Thornton	762364	300	91	6·0	9·6	39·0	54·0	−15·0	Open site. Ground falling at shallow angle in front.
16	A.5. North of Bletchley	872348	250	76	4·5	7·2	11·0	27·0	−16·0	Open site beside main road. Telephone wires 60 ft in front.
Fixed Site	Mursley	825291	520	128	–	–	Site Variation Factor −7·5 dB			Open site at crest of gradually sloping terrain.

(Field strengths are expressed in dB relative to 1 μV/m for 1 kW E.R.P.)

SITE VARIATION FACTOR – MEASUREMENTS MADE IN OTTRINGHAM AREA

TRANSMISSION FROM PONTOP PIKE – BAND IV (560 Mc/s)

Test No.	Site Location	Grid Reference (100 km square TA)	Site Height (a.m.s.l.)		Distance from Fixed Site		Field Strength		Comparison of Field Strength of Temporary with Fixed Site (dB)	Site Details
			ft	m	ml	km	Temporary Site (dB)	Fixed Site (dB)		
1	The Shrubbery	262211	10	3·0	2·1	3·4	+2·5	+1·0	+1·5	Flat ground. Farm ¼ mile at rear. Telephone wires 15 yd to right also trees.
2	The Colony	296263	88	26·8	1·75	2·8	+2·0	+0·5	+1·5	Flat, open ground. Trees 100 ft to rear.
3	Bunkers Hill	291277	40	12·2	2·4	3·9	+8·0	+7·0	+1·0	Open fields at front rising to just over 50 ft at 350 yd. Trees on horizon and at 50/100 yd at 10° to right.
4	Nr. Thorngumbald	208255	10	3·0	4·5	7·2	+3·0	+2·5	+0·5	Flat ground in all directions.
5	Nr. North End Farm	275262	20	6·1	1·3	2·1	+10·0	+10·0	0	Flat open site.
6	North Farm	350222	70	21·3	4·6	7·4	−0·5	−0·5	0	Undulating ground to horizon. Trees at ½ mile.
7	Nr. Keyingham Grange	240231	15	4·5	2·5	4·0	+3·25	+3·25	0	Flat. Farm buildings ¼ mile in front. Telephone wires 25 yd at rear.
8	Nr. Ryhill	231261	25	7·6	3·2	5·2	+2·5	+3·5	−1·0	Open ground. Trees at rear and sides of aerial. Telephone wires at rear.
9	Hallfield	213292	35	10·6	5·2	8·4	+0·25	+1·25	−1·0	Open ground, dropping slightly in front of aerial. Slight undulations to horizon. Farm buildings 50 yd to rear.
10	Rimswell	318281	50	15·2	3·5	5·6	+3·5	+4·5	−1·0	Open ground rising slightly at front.
11	Nr. Elmtree Cottage	259296	20	6·1	3·6	5·8	+3·5	+5·0	−1·5	Open ground. Trees on horizon. Power lines at 200 yd (20 ft a.g.l.). House 600 yd in front.
12	Waxholme	327301	50	15·2	4·8	7·7	+5·0	+7·0	−2·0	Open ground. Sea to right and rear.
13	Nr. Tunstall	297314	60	18·3	4·7	7·6	+3·0	+6·0	−3·0	Flat site rising to 70 ft at horizon. Trees on horizon.
14	Nr. Patrington	327218	45	13·7	3·3	5·3	+5·0	+9·0	−4·0	Open ground. Slightly undulating. Trees ¼ mile in front.
15	Eastgrowths Farm	301205	14	4·2	2·6	4·2	+2·0	+6·5	−4·5	Flat ground. House 15 yd to right.
16	Nr. Winestead White Hall	294242	25	7·6	1·0	1·6	+2·0	+7·0	−5·0	Open ground rising to 35 ft. Wood at ¼ mile 20° to right. Main road at rear (50 yd) and wood on far side.
17	Nr. Mile House	326238	40	12·2	3·0	4·8	+7·0	+13·0	−6·0	Open ground rising to 80 ft at 1 mile with trees. Power lines (20 ft a.g.l.) at ¼ mile also 200 yd to rear.
18	Eastholme	252279	8	2·4	2·9	4·7	+5·0	+12·5	−7·5	Flat site. Ground rising to 40 ft at 2/3 mile. Trees (40 ft at 250 yd.)
19	Nr. The Elms	292294	10	3·0	3·4	5·5	+5·0	+17·5	−12·5	Site approx. 150 yd from Band III site. Tree lined road 150 yd to left. Hill at 200 yd rising to 50 ft. Probably a worse site due to proximity of hill.
Fixed Site	Ottringham	279239	30	9·1	–	–	Site Variation Factor −2·5 dB			Flat terrain in vicinity of site.

(Field strengths are expressed in dB relative to 1 μV/m for 1 kW E.R.P.)

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